behaviors by the Porsolt forced swim test, and locomotor activity and anxiety by the open field test. We also studied adult neurogenesis within the hippocampal dentate gyrus by using the thymidine analogue BrdU to label replicating stem cells. Ten months after irradiation animals were killed and brain tissue used for histology and immunohistochemistry.
Results: Microbeam irradiation did not alter cognitive performance. Interestingly, microbeam irradiation (300 Gy) significantly reduced the immobility time in the forced swim test without affecting locomotor activity as compared to control rats and 5-10 Gy irradiated rats. Histological analysis showed that microbeam irradiation did not alter the cytoarchitecture of the hippocampus with cell death observed only along the irradiation pathway. We did not observe a reduction of hippocampal neurogenesis, assessed by stereological counts of BrdU-positive cells in the dentate gyrus of the hippocampus at 10 months after microbeam irradiation.
Conclusions: These data shed light on the biological effects of microbeam irradiation on the CNS and may open new potential therapeutic strategies in cancer treatment and other CNS disorders.
Keywords: Microbeam radiation therapy, Hippocampus, Neurogenesis

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What are the Dominant Radiobiological Mechanisms at Play in Stereotactic Radiotherapy?
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Recent clinical results using Stereotactic Radiation Therapy (SRT) are very encouraging. Our goal is to investigate whether the excellent SRT tumor control data imply that there are new tumoricidal mechanisms that determine tumor control at high SRT doses – new mechanisms which are not present or have little effect at conventional radiotherapeutic doses.
To accomplish this, we investigate whether the standard LQ model with heterogeneity can provide as good a description of the SRT data as can models with extra terms describing unique high-dose tumor control mechanisms.
We analyzed published TCP data for lung tumors or brain metastases from 3000 SRT patients, covering a wide range of doses and fraction numbers. We used: (a) a linear-quadratic model (including heterogeneity), which assumes the same mechanisms at all doses, and (b) alternative models with terms describing distinct tumoricidal mechanisms at high doses.
Both for lung and brain data, the LQ model provided a significantly better fit over the entire range of treatment doses than did any of the models requiring extra terms at high doses. Analyzing the data as a function of fractionation (1 fraction *vs*. >1 fraction), there was no significant effect on TCP in the lung data, whereas for brain data multi-fraction SRT was associated with higher TCP than single-fraction treatment.
This analysis suggests that distinct tumoricidal mechanisms do not determine tumor control at high doses/fraction. Rather the excellent clinical outcomes seen with SRT are the result of the excellent dose distributions which SRT provides, which allow delivery of larger doses to the tumor than is possible with conventional radiotherapy. Finally, there is plausible evidence suggesting that multi-fraction SRT is superior to single-dose SRT.

Keywords: Stereotactic Radiotherapy Mechanisms

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GEANT4 simulation of dose deposition in patients from TomoTherapy Hi-Art Megavoltage computed tomography (MVCT) imaging.
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Purpose: Image-guided radiotherapy (IGRT) is a technique used to optimise RT beam delivery to the tumour by following its evolution over time through regular MVCT imaging of the treatment area.
However, its application is limited by clinical concerns over the additional dose coming from MVCT imaging, which we evaluate in this study.
Methods: We use the particle transport framework GEANT4[1] to model the X-ray beam line from the Tomotherapy Hi-Art RT treatment machine at the Addenbrooke's hospital and evaluate the imaging dose delivered to the vicinity of the tumour. Dose maps are obtained by combining simulations of the CT scan using a static beam line with 51 different exposition angles.
All GEANT4 simulations were performed on UK grid resources[2] to maximize parallel throughput, using anonymised data.
Results: Simulated beam profiles (PDD, longitudinal and lateral) with different MLC beam patterns were compared to actual calibration data taken in water tank at Addenbrooke's hospital. The agreement between the model and the calibration is quantified by the Gamma index[3]. Less than 2% of the simulated points exceed Gamma(1%,1mm)
We also simulated the imaging dose distribution in a prostate patient treated in 34 fractions, each fraction starting with one MV CT used for image guidance. We used a fan beam width of 4 mm with a pitch of 2 mm. The results are shown in Figure 1.

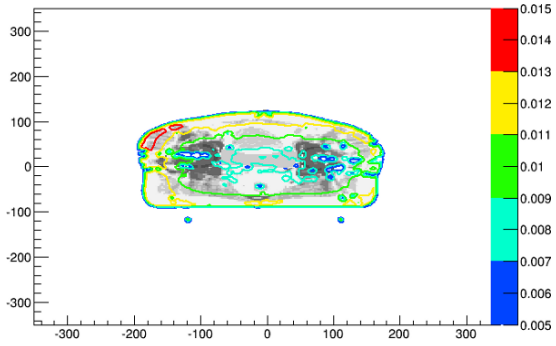

Figure 1: Normalised imaging dose distributions in Gy for a prostate cancer patient, in a transverse plane in the treatment region.

The maximum simulated dose is about 1.5 cGy on a single MVCT, in agreement with results found in [4] using proprietary software. For comparison, the treatment dose in the same area goes up to 2 Gy per fraction.
Conclusions: We have successfully modeled the Megavoltage imaging beam line of the Tomotherapy Hi-Art machine used for radiotherapy at the Addenbrooke's hospital using Geant 4 and used it to derive dose maps in the patient.
Doses were found to be in agreement with other published results and negligible with respect to the treatment dose.

Keywords: MVCT, dose, Monte-Carlo, Geant4

References: